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What USCID Members Should Know about Safety around Low-Head Dams

by Kenneth R. Wright, P.E., Wright Water Engineers, Inc., Denver, Colorado

What are Low-Head Dams?

Many USCID members are familiar with low-head dams. Low-head dams are underwater structures typically 5- to 15-feet high that are designed and built to span a waterway such that water continuously flows over the crest from bank to bank. Low-head dams were constructed throughout the United States for such purposes as milling, navigation, irrigation, municipal water supply and hydropower. Many no longer serve their original purpose, but they have not been removed. Low-head dams are often not regulated because their low height does not pose a significant flood danger in the case of a breach.

This irrigation diversion on the Cache la Poudre River in Colorado is an example of a low-head dam (WWE).

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Managing Groundwater Overdraft — Combining Crop and Water Decisions

by Yiqing "Gracie" Yao and Jay Lund, University of California, Davis, Davis, California

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California's Central Valley produces much of the nation's food, including about 40 percent of the country's fruits and nuts and has the nation's second most pumped aquifer system. Its drier southern portion, the San Joaquin Valley, has decreasing surface water supply reliability due to frequent and prolonged droughts, stricter environmental regulations, and growing competition among water users. Many farmers pump groundwater to provide their unsupplied water demand. The resulting groundwater overdraft has numerous impacts on the Valley's agriculture and residents. The 2014 Sustainable Groundwater Management Act (SGMA) requires local water agencies to end a decades-long overdraft (averaging about 2 maf/year) and bring groundwater basins into sustainable use by about 2040, a major challenge for San Joaquin Valley agriculture (Escriva-Bou et al. 2020).

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President's Message

One of the hardest parts of writing the President's Message is coming up with ideas. But, my last article on history of the regime theory generated a lot of interest and I received several emails regarding that. So, I decided to build on that and talk about regime theory closer to home: the design of the All-American Canal in the Imperial Irrigation District. The All-American Canal was part of the U.S. Bureau of Reclamation's Boulder Canyon Project. It was included in the Boulder Canyon Project Act of 1928 that authorized the construction of Hoover Dam (an excellent book on this topic is *Colossus* by Michael Hiltzik).

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Salinity and High Water Tables

by Alejandro Paolini, Henry Miller Reclamation District 2131, Dos Palos, California

San Luis Canal Company (SLCC) obtains its water supply through an Exchange Contract with the Bureau of Reclamation. The Exchange Contract allows SLCC to receive its water through the Delta-Mendota Canal (DMC). Henry Miller Reclamation District 2131 (HMRD) was formed in FY2000. It works in conjunction with SLCC to deliver the irrigation water and

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Inside . . .

Low-Head Dams (continued)

At certain river flow levels, however, many low-head dams develop a dangerous hydraulic reverse roller at the toe that can trap people and watercraft. Watercraft often capsize in the churning water and a person can be circulated through the water so quickly and in such a confusion of bubbles that they do not know which way is up. Without immediate help, even strong swimmers trapped in these recirculating currents can become exhausted and drown. As a result, low-head dams are often referred to in literature as "drowning machines."

Dangers at low-head dams are exacerbated by the fact that the pooled water above the dams often appears placid. People going down the river in a watercraft do not see the churning water at the toe of the dam until they are in it. These dangers are hard to anticipate because the reverse rollers are not present under all flow conditions. Some tailwater flow levels are too shallow to allow a reverse roller to form.

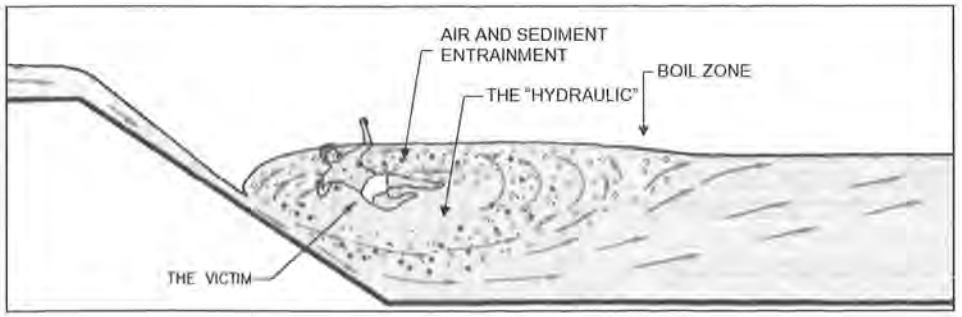
As water flows over a dam, it forms an acceleration jet that plunges into the tailwater carrying with it entrained air. The jet, after diving downward and following the streambed, rises upward to the surface creating a type of aerated "boil." A portion of the water in this dissipated jet flows downstream and a portion of the flow reverses itself to flow back to the dam, in effect creating a "reverse roller," which is then influenced at the base of the dam by the falling water jet. This sets up a roller that can go around and around. Overall, this phenomenon represents a submerged hydraulic jump. If the tailwater depth is less than the subsequent depth, the reverse roller will not form. On the other hand, if the tailwater depth is far higher than the subsequent depth, the submerged hydraulic jump will be "washed out" and no reverse roller will form (Tschantz and Wright 2011).

More than 1,400 fatalities have been documented at or around low-head dams (Israel 2020); victims have included recreationists, rescue personnel, dam owners, and maintenance personnel. It is critical that those who are aware of the presence and danger of low-head dams in their communities take necessary steps to save lives.

What Can be Done about Hazardous Low-Head Dams?

As part of USCID's mission to "...promote social and environmental goals," there are many ways members can help alleviate the problem of hazardous low-head dams. The most common approaches to decreasing drownings at low-head dams are public awareness, signage, retrofitting/ modification, and removal.

Public awareness programs that promote safety education and understanding of the potential dangers at low-head dams are key. The average water recreationists and rescue workers need to know that low-head dams can be dangerous, what to look for, and which dams in their area have the potential to develop a dangerous reverse roller. Recreational activities, such as kayaking, rafting, tubing and fishing, are the most susceptible to low-head dam hazards as they come in direct, or close, contact with low-head dams. Strategic placement of signage to warn of these dangers can greatly reduce the number of fatalities that occur from inexperience and lack of knowledge of low-head dam dangers. In addition,



A boil or reverse roller can trap unsuspecting recreationists and rescue workers (WWE).

The Colorado Department of Natural Resources recently had this sign installed along Brush Creek in Colorado (Colorado DNR).

many state river guides include information about what to look for, and how to avoid, these hazards.

Websites, social media, print media, television, video, workshops, schools, sports equipment rental shops and community organizations are all outlets through which the public can become better informed about the possible dangers around low-head dams. Governmental agencies like departments of natural resources can and should play a role in identifying potential hazards and evaluating risks to help put the issue into perspective and to prioritize the needs. Engineering schools can also improve public safety by educating their students about the issue and its remedies.

Installing warning signs and buoys at low-head dams with histories of accidents is a relatively inexpensive method of warning the public of the existence of a potential hazard. Signs need to be clear, obvious, and placed in a location that provides ample warning to people in watercraft so they can portage around the low-head dam. This option can hinge on access to public land or easements for portage purposes.

Retrofitting or modification of a low-head dam is a solution that can resolve the problem of a hazardous reverse roller there. Practical alternatives include the use of engineered structures like stepped spillways, gabion baskets, flat slopes, cascading pools or dumped rock to dissipate energy and eliminate the

The Island Farm Weir in New Jersey featured a dangerous reverse roller (above, Bruce Tschantz), until a baffled fish ladder was retrofitted in 2013 (below, Paul Schweiger).

hydraulic. The key to a successful low-head dam retrofit is to dissipate energy and to eliminate the opportunity for a submerged jump and reverse roller to form below the dam structure. Chutes can also be incorporated into low-head dams to accommodate boaters more safely.

A movement has been afoot in the U.S. to remove unneeded dams for a variety of reasons, such as environmental rehabilitation, flood control, structural weakness and maintenance expense (Struck 2014). These modifications eliminate the reverse rollers, which provides the added benefit of eliminating potential fatalities.

What is Happening Now to Improve Safety around Low-Head Dams?

As the death toll rises year after year from low-head dam accidents, many groups have stepped up to identify and mitigate low-head dam hazards. Over the past 18 months, a task force involving members of the American Society of Civil Engineers Environmental and Water Resources Institute, the Association of State Dam Safety Officials (ASDSO), and the U.S. Society on Dams has been developing a national inventory of low-head dam locations. Although low-head dams exist throughout the U.S., there are greater concentrations in the Northeast, where they were previously used to generate power for mills, and in western states where they are used for irrigation.

Some states have taken it upon themselves to identify low-head dam locations and promote education of the public. For example, in October 2020, the Colorado Department of Natural Resources announced its "new initiative to reduce deaths and accidents around low head dams." It has identified more than 1,100 low-head dams and provided those locations on their website, along with general information about what low-head dams are, why they are dangerous, and safety guidance around those dams (https://dnr.colorado.gov/initiatives/colorado-low-head-dams).

Another group is collaborating on a nationwide faculty outreach program. **Kenneth Wright**, P.E., long-time low-head dam safety advocate; his wife Ruth, a former Colorado legislator; Robert Houghtalen, adjunct professor at the University of North Carolina–Wilmington; Rollin Hotchkiss, professor at Brigham Young University; and Wright Water Engineers, Inc., founded by Kenneth Wright, have created a package of information that is being distributed to engineering faculty throughout the U.S. The information, consisting of videos, technical material, and a presentation, can be used as lecture material. The hope is that raising awareness now among future engineers will have a substantial impact on future hazard mitigation, and perhaps even save lives.

Kenneth Wright, as a member of ASDSO, is also providing safety lectures throughout Colorado to water rescue and fire department personnel. These "drowning machines" don't discriminate, and many rescue personnel have lost their lives trying to save other victims because they were not aware of the "reverse roller" phenomenon.

Works Cited

Israel, Benjamin. 2020. Personal Communication re: Association of State Dam Safety Officials Fatalities Database. July 22.

Kingery, Karl, Kenneth Wright, and Rollin Hotchkiss. 2020. Considerations Surrounding the Rehabilitation and Removal of Low-Head Dams. In Association of State Dam Safety Officials 2020 Annual Conference Proceedings. September 21.

Struck, Doug. 2014. Setting rivers free: As dams are torn down, nature is quickly recovering.

Christian Science Monitor. Retrieved December 3, 2020. https://www.csmonitor.com/ Environment/2014/0803/Setting-rivers-free-As-dams-are-torn-down-nature-is-quickly-recovering.

Tschantz, Bruce, and Kenneth Wright. 2011. Public Safety at Low Head Dams. *Association of Dam Safety Officials Journal of Dam Safety.* May. Volume 9: # 2.□

Necrology

Wayne Clyma passed away on March 19, 2021. He was retired from Colorado State University. He was 85 and joined USCID in 1979

George F. Horowitz passed away on December 27, 2020. He joined USCID in 1974 and was 96.

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